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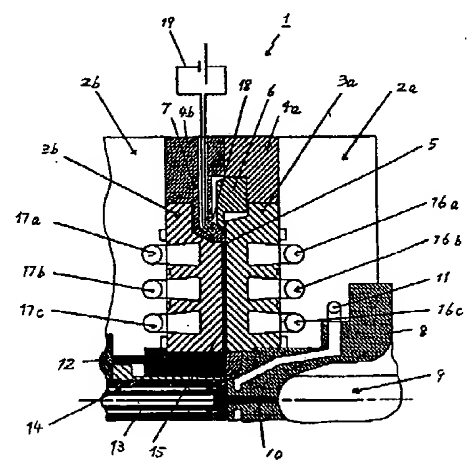
Remarks:
Amended claims in accordance with Rule 86 (2) EPC.

(54) **Method of and apparatus for molding with multiple temperature adjusting channels**

(57) In a method of and an apparatus for molding a plastic, a molten material is supplied through the injection nozzle (9), the sprue channel (10) and the gate into the cavity (15) formed by the two halves of mirror (3a and 3b) and the stamper (5) and the outer mirror ring (7). Each mirror is provided with a plurality of separate temperature adjusting channels (16a, 16b, 16c, 17a, 17b and 17c) in which temperature adjusting medium like water or gas flows. The outer mirror ring (7) is provided with additional temperature adjusting member such as an electrical heater (19). The temperature adjusting medium have such temperature distribution or profile that the temperature of the medium flowing the temperature adjusting channel (16a) in the outer radius is higher than the temperature of the medium flowing the temperature adjusting channel (16b and 16c) in the one half of the mold and the temperature of the medium flowing the temperature adjusting channel (17 a) in the outer radius is lower than the temperature of the medium flowing the temperature adjusting channel (17b and 17c) and the temperature of the electric heater (19) is higher than the temperature of the medium flowing the temperature adjusting channel (17a) in the outer radius.

Fig. 1



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Description

The invention relates to method of and apparatus for molding, and more specifically to method of and apparatus for molding with multiple temperature adjusting channels to enable production more efficiently.

In a process of producing plastics, hot molten raw material is injected through an injection nozzle and a sprue channel or extension gate and/or a runner channel into the cavity formed by the closed mold. After the molded plastics is cooled down, the mold is opened and the molded plastics is removed or unloaded from the mold.

In general, such molded plastics is apt to have outward defects such as a weld line and/or shrink near the gate. Also distortion may be caused within the molded plastics because of injection pressure, lack of temperature distribution uniformity, and molecules orientations caused while the molten material flows in the cavity.

In case of production of substrate of optical disc, the quality of an optical disc is defined by the geometrical dimensions as well as its optical characteristics such as refraction index or birefringence. One of the geometrical dimensions is determined by the quality of the inverse replication of the stamper and which has the order of about 100nm. The optical quality is mainly determined by prevailing orientations of the molecules of the injected material and by the stress frozen in the molded material.

In order to achieve good quality in geometric dimensions and optical characteristics of the optical disc, therefore, it is necessary to inject the material with a temperature at which the material is plasticized as enough as possible and not to inject the material below about 300°C. On the other hand, it is necessary to cool dawn the material below its glass temperature (below 140°C) to avoid deformation during unload from the mold. The time period from when the molten material is injected to when the molded substrate can be removed is defined as the cooling time. In order to reduce the cooling time, it is necessary to increase the cooling rate.

In general, however, the faster the material is cooled dawn (the cooling rate), the more prevailing orientations and stress caused during the injection are frozen in the molded material.

As conventional mold has an equal temperature distribution along the geometry, the injected molten material is earlier cooled down in the outer radius of the cavity than near the gate so that a temperature difference is caused between the outer radius of the cavity and near the gate. If the cooling rate is very high, the temperature of the injected material decreases with this temperature gradient and this leads the molded optical disc to an inhomogenious distribution of the frozen prevailing orientations and the remaining stress from the inner to the outer in the direction of radius of the disc.

It is also known to heat the cavity over the melting point of the injected material before and during injection and then cooling the cavity after injection. However, in the case of injection molding, the production cycle time is mainly determined by the cooling time which is about 50% of the production cycle time. Therefore, this known process makes the production cycle time longer, because it is not possible to switch from heating to cooling within a few seconds.

According to the invention, this problem is solved by a method or apparatus in that the molding is done with a defined temperature profile of the mold along the material flow within the cavity. This allows to reduce the cooling time during the injection molding process with the consequence of shorter production cycle times without deteriorating the quality of the molded products.

The invention will now be described by way of examples and with reference to the accompanying drawings in which:

Fig. 1 is a schematic drawing showing a sectional view of a part of an injection molding machine in accordance with the invention.

Figs. 2 is a schematic drawing showing a sectional view of the mirror of the injection molding machine shown in Fig. 1.

Referring to Figs. 1 and 2, an embodiment of the injection molding machine 1 in accordance with the invention is explained. In this embodiment, the injection molding machine 1 is designed for production of plastic substrates of optical discs such as compact discs.

The injection molding machine 1 includes the stationary die plate 2a on the right side and the movable die plate 2b on the left side. The stationary die plate 2a is attached with the stationary minor 3a and the spacer 4a. The stamper 5 is mounted on the stationary mirror 3a by means of the stamper ring 6 attached on the spacer 4a. The movable die plate 2b is attached with the movable mirror 3b which is also called as a mirror stamper and the spacer 4b. The spacer 4b is attached with the outer mirror ring 7 by which the diameter of the substrate to be molded is defined.

The stationary die plate 2a is further provided with the sprue bush 8 in which the nozzle 9, the sprue channel 10 and the cooling channel 11 are formed. The movable die plate 2b is further provided with the center bush 12 in which the bunch 13 and the cooling channel 14 is contained. The sprue bush 8 and the center bush 12 takes place at the center of the mirrors 3a and 3b due to the rotational symmetry of the substrate. Fig. 1 shows only upper half of the molds.

At the beginning of every injection cycle, the movable die plate 2b is moved toward the stationary die plate 2a so that the two mirrors 3a and 3b are closed together with the outer mirror ring 7 to form a cavity 15 corresponding the shape of the substrate.

The molten and plasticized material is injected into the cavity 15 through the nozzle 9, the sprue channel 10

and the gate provided between the sprue channel 10 and the cavity 15. The injected material flows toward the outer radius of the cavity 15 along the mirror stamper 3b and the stamper 5 from which the data information are replicated on the substrate.

During the production, water of 20 to 30°C flows through the channel 11 in the sprue channel region and through the channel 14 in the bunch region.

In this embodiment, the separate, for example three, independent channels 16a, 16b, and 16c are provided to the stationary mirror 3a. Similarly, the separate, for example three, independent channels 17a, 17b, and 17c are provided to the movable mirror 3b. The course of the channels 16a, 16b, and 16c as well as the channels 17a, 17b, and 17c are formed for example concentric circles respectively as shown in Fig. 2. These channels 16a, 16b, 16c, 17a, 17b and 17c are supplied with medium like a fluid such as water or gas of different temperatures flowing therethrough.

The temperature conditions of the fluid supplied through the channels 16a, 16b, and 16c as well as the channels 17a, 17b, and 17c are adjusted so that the cooling time can be minimized. The temperature profile of the fluid are, for example, 85°C, 80°C and 80°C in the channels 16a, 16b, and 16c, respectively and 50°C, 80°C and 80°C, in the channels 17a, 17b, and 17 c, respectively. The above temperatures of the fluid are measured near the channels 16a, 16b, 16c, 17a, 17b, and 17c, respectively.

Furthermore, the outer mirror ring 7 is provided with a groove 18 where an electric ring heater 19 is provided to maintain the outer region of the substrate at 80°C, for instance. This groove 18 can be replaced with a channel through which a medium like heated water flows.

After the molded substrate is cooled down, the mold is opened and the molded substrate is removed from the movable mirror 3b.

According to the above described temperature profile, the cooling time can be reduced from 7 seconds to 5 seconds, for example. The above temperature profile can be modified according to the other conditions of the production.

The invention can be applied to production of optical components such as optical lens. However, it is also possible to apply this invention to any other types of molding machines or methods, or any other products than the above embodiment.

The shape of each channel 17a to 17c and 17a to 17c is not limited to the concentric circle and also possible to be concentric square or any other form.

Claims

1. A method of molding a plastic comprising steps of: closing the mold (3a, 3b, 5, and 7) to form a cavity (15); injecting molten material into the cavity (15); cooling the injected material; opening the mold; removing the molded plastic from the mold; characterized in that: said step of cooling the molten material includes cooling the molten material by temperature adjusting means having different temperatures.

2. A method of molding a plastic as claimed in Claim 1, characterized in that said step of cooling the molten material includes cooling the molten material by a plurality of separate temperature adjusting means (16a, 16b, 16c, 17a, 17b, 17c and 19) having different temperatures.

3. A method of molding a plastic as claimed in Claim 1, characterized in that said step of cooling the molten material includes cooling the molten material by fluid flowing through a plurality of separate temperature adjusting channels (16a, 16b, 16c, 17a, 17b, 17c) and by an electric heater (19).

4. A method of molding a plastic as claimed in Claim 1, characterized in that the temperature of the temperature adjusting means in the outer radius of the cavity is higher than in the inner radius of the cavity in one half of the mold and the temperature of the temperature adjusting means in the outer radius of the cavity is lower than in the inner radius of the cavity in the other half of the mold.

5. A method of molding a plastic as claimed in Claim 1, characterized in that said step of cooling the molten material includes cooling the molten material by a plurality of separate temperature adjusting means (16a, 16b, and 16c) provided in the radial direction of one half of the mold and the plurality of separate temperature adjusting means (17a, 17b and 17c) and additional temperature adjusting means (19) provided in the radial direction in the other half of the mold and the temperature of the temperature adjusting means (16a) in the outer radius of the cavity is higher than the temperature of the temperature adjusting means (16b and 16 c) in the inner radius of the cavity in the one half of the mold and the temperature of the temperature adjusting means (17a) in the outer radius of the cavity is lower than the temperature of the temperature adjusting means (17b and 17c) in the inner radius of the cavity in the other half of the mold and the temperature of the additional temperature adjusting means is also higher than the temperature of the temperature adjusting means (17a) in the outer radius of the cavity in the other hald of the mold.

6. An apparatus for molding a plastic comprising: mold means (3a, 3b, 5, 7) forming a cavity (15); injection means (9, 10) for injecting the molten material into the cavity (15); temperature adjusting means (16a, 16b, 16c, 17a, 17b, 17c and 19) for cooling the injected material; characterized by; said

temperature adjusting means have different temperatures.

7. An apparatus for molding a plastic as claimed in Claim 6, characterized in that said temperature adjusting means include a plurality of separate temperature adjusting means having different temperatures.

8. An apparatus for molding a plastic as claimed in Claim 6, characterized in that the temperature adjusting means includes fluid flowing through a plurality of separate temperature adjusting channels (16a, 16b, 16c, 17a, 17b, 17c) and an electric heater (19).

9. An apparatus for molding a plastic as claimed in Claim 6, characterized in that the temperature of the temperature adjusting means (16a) in the outer radius of the cavity is higher than in the inner radius of the cavity in one half of the mold and the temperature of the temperature adjusting means (17a) in the outer radius of the cavity is lower than in the inner radius of the cavity in the other half of the mold.

10. An apparatus for molding a plastic as claimed in Claim 1, characterized in that said temperature adjusting means include a plurality of separate temperature adjusting means (16a, 16b and 16c) provided in the radial direction of one half of the mold and the plurality of separate temperature adjusting means (17a, 17b and 17c) and additional temperature adjusting means (19) provided in the radial direction in the other half of the mold and the temperature of the temperature adjusting means (16a) in the outer radius of the cavity is higher than the temperature of the temperature adjusting means (16b and 16c) in the inner radius of the cavity in the one half of the mold and the temperature of the temperature adjusting means (17a) in the outer radius of the cavity is lower than the temperature of the temperature adjusting means (17b and 17c) in the inner radius of the cavity in the other half of the mold and the temperature of the additional temperature adjusting means is also higher than the temperature of the temperature adjusting means (17a) in the outer radius of the cavity in the other hald of the mold.

Amended claims in accordance with Rule 86(2) EPC.

1. A method of molding a plastic comprising steps of: closing the mold (3a, 3b 5, and 7) to form a cavity (15); injecting molten material into the cavity (15); cooling the injected material, by a plurality of separate temperature adjusting means (16a, 16b, 16c, 17a, 17b, 17c and 19) having different temperatures, opening the mold; removing the molded plastic from the mold; characterized in that step of cooling the molten material includes cooling the molten material by fluid flowing through a plurality of separate temperature adjusting channels (16a, 16b, 16c, 17a, 17b, 17c) and by an electric heater (19).

2. A method of molding a plastic as claimed in Claim 1, characterized in that the temperature of the temperature adjusting means in the outer radius of the cavity is higher than the inner radius of the cavity in one half of the mold and the temperature of the temperature adjusting means in the outer radius of the cavity is lower than in the inner radius of the cavity in the other half of the mold.

3. A method of molding a plastic as claimed in Claim 1, characterized in that said step of cooling the molten material includes cooling the molten material by a plurality of separate temperature adjusting means (16a, 16b and 16c) provided in the radial direction of one half of the mold and the plurality of separate temperature adjusting means (17a, 17b and 17c) and additional temperature adjusting means (19) provided in the radial direction in the other half of the mold and the temperature of the temperature adjusting means (16a) in the outer radius of the cavity is higher than the temperature of the temperature adjusting means (16b and 16c) in the inner radius of the cavity in the one half of the mold and the temperature of the temperature adjusting means (17a) in the outer radius of the cavity is lower than the temperature of the temperature adjusting means (17b and 17c) in the inner radius of the cavity in the other half of the mold and the temperature of the additional temperature adjusting means is also higher than the temperature of the temperature adjusting means (17a) in the outer radius of the cavity in the other hald of the mold.

4. An apparatus for molding a plastic comprising: mold means (3a, 3b, 5, 7) forming a cavity (15); injection means (9, 10) for injecting the molten material into the cavity (15); a plurality of separate temperature adjusting means having different temperatures (16a, 16b, 16c, 17a, 17b, 17c and 19) for cooling the injected material, characterized in that the temperature adjusting means includes fluid flowing through a plurality of separate temperature adjusting channels (16a, 16b, 16c, 17a, 17b, 17c) and an electric heater (19).

5. An apparatus for molding a plastic as claimed in Claim 4, characterized in that the temperature of the temperature adjusting means (16a) in the outer

radius of the cavity is higher than in the inner radius of the cavity in one half of the mold and the temperature of the temperature adjusting means (17a) in the outer radius of the cavity is lower than in the inner radius of the cavity in the other half of the mold.

6. An apparatus for molding a plastic as claimed in Claim 4, characterized in that said temperature adjusting means include a plurality of separate temperature adjusting means (16a, 16b and 16c) provided in the radial direction of one half of the mold and the plurality of separate temperature adjusting means (17a, 17b and 17c) and additional temperature adjusting means (19) provided in the radial direction in the other half of the mold and the temperature of the temperature adjusting means (16a) in the outer radius of the cavity is higher than the temperature of the temperature adjusting means (16b and 16c) in the inner radius of the cavity in the one half of the mold and the temperature of the temperature adjusting means (17a) in the outer radius of the cavity is lower than the temperature of the temperature adjusting means (17b and 17c) in the inner radius of the cavity in the other half of the mold and the temperature of the additional temperature adjusting means is also higher than the temperature of the temperature adjusting means (17a) in the outer radius of the cavity in the other hald of the mold.

Fig. 1

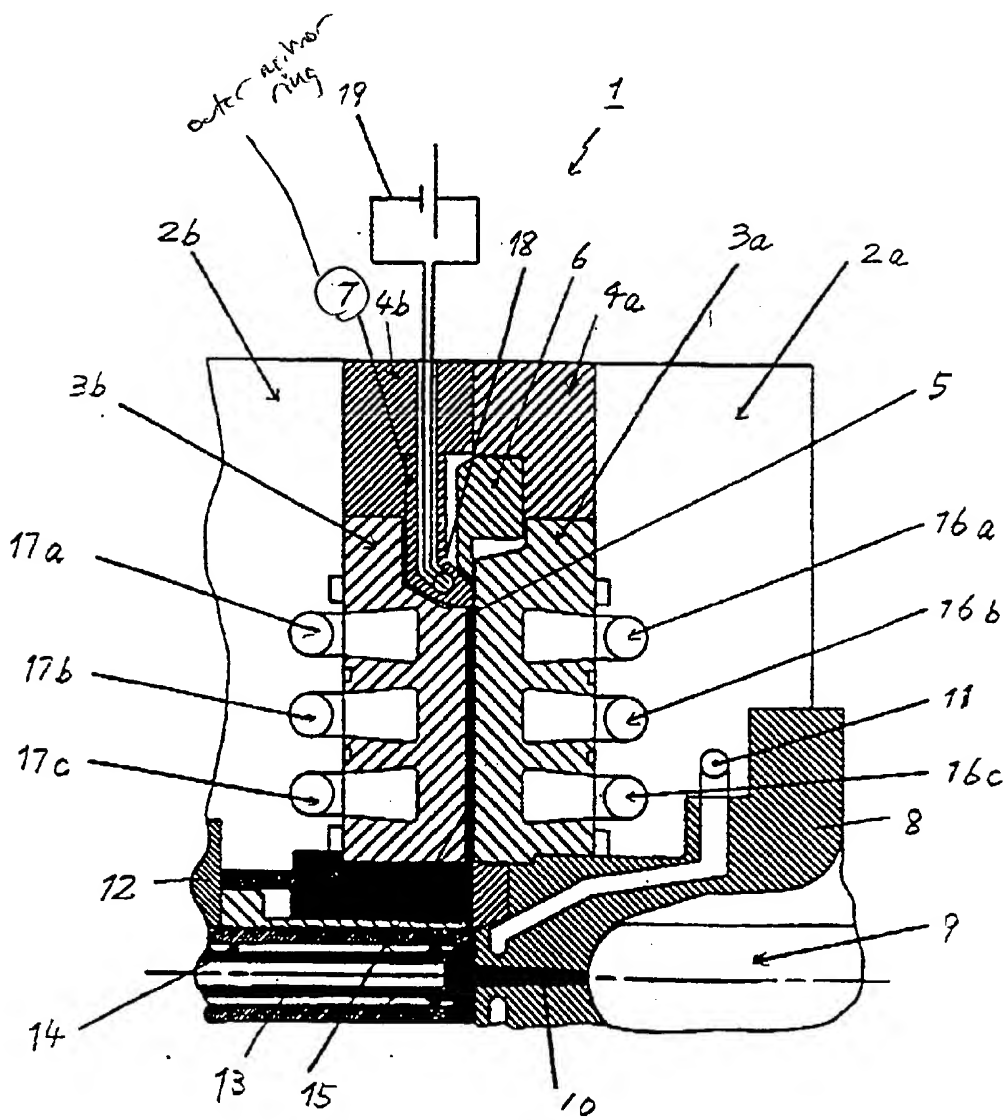
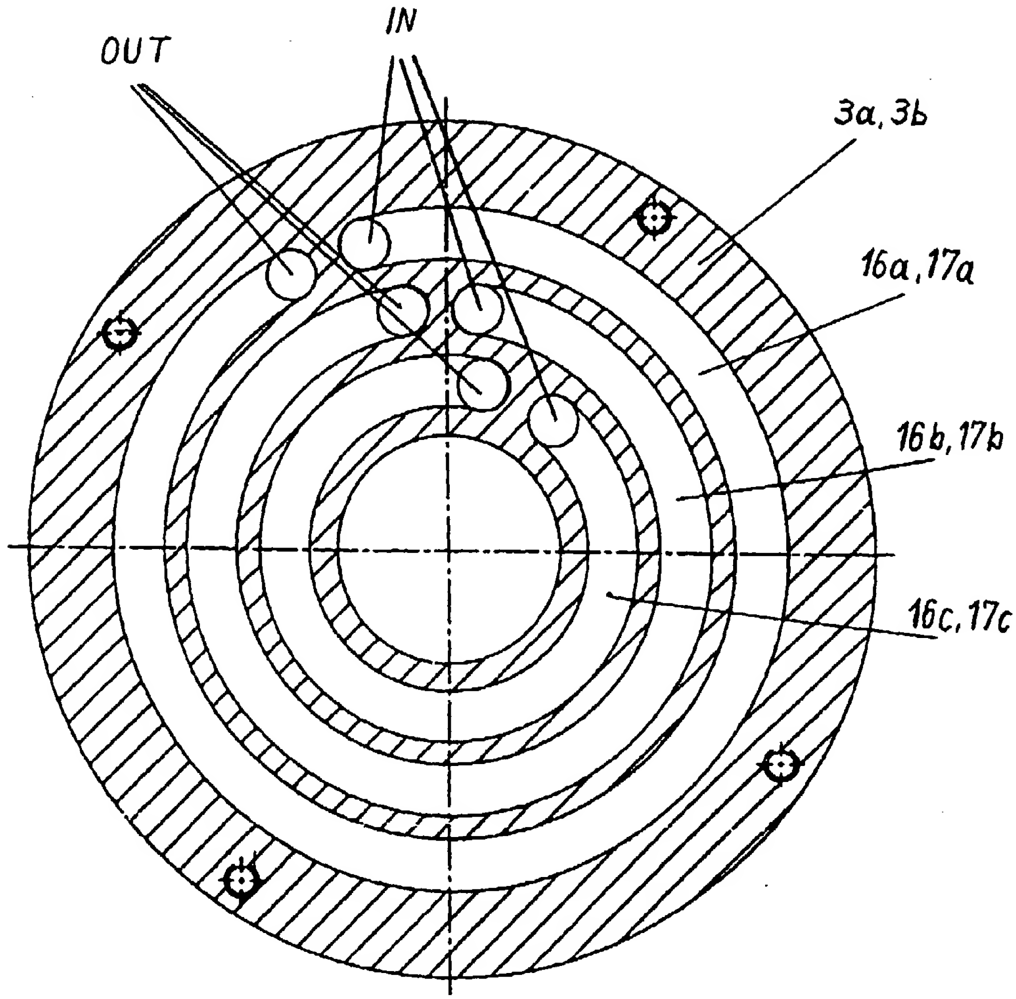

outer actuator ring
19
1
2b
18
6
3a
2a
7
4b
4a
3b
5
17a
16a
16b
17b
11
17c
16c
8
12
9
14
13
15
10

Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 96 89 0181

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 8, no. 80 (M-289) [1517] , 12 April 1984 & JP 58 224730 A (PIONEER KK), 27 December 1983, * abstract * ---	1,2,6,7	B29C45/73
X	PATENT ABSTRACTS OF JAPAN vol. 13, no. 528 (M-898) [3876] , 24 November 1989 & JP 01 216807 A (TOSHIBA CORP), 30 August 1989, * abstract * ---	1,2,6,7	
X	US 3 191 225 A (E.F. POLKA) 29 June 1965 * the whole document * ---	1,2,6,7	
X	CH 507 802 A (SYNTHEXA) 31 May 1971 * column 9, line 39 - column 10, line 6; figures 2-4 * ---	1,2,6,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
X	DE 44 18 452 A (KONICA CORP.) 1 December 1994 * the whole document * ---	1,2,6,7	B29C
X	US 4 437 641 A (STAVITSKY DAVID ET AL) 20 March 1984 * the whole document * ---	1,2,6,7	
X	PATENT ABSTRACTS OF JAPAN vol. 18, no. 496 (M-1674), 16 September 1994 & JP 06 166076 A (HITACHI MAXELL LTD), 14 June 1994, * abstract * --- -/--	1,6	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 April 1997	Bollen, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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X	PATENT ABSTRACTS OF JAPAN vol. 96, no. 4, 30 April 1996 & JP 07 329137 A (MITSUBISHI CHEM CORP), 19 December 1995, * abstract * ---	1,6	
X	EP 0 122 207 A (LANDRY PLASTIQUES SUD) 17 October 1984 * the whole document * ---	1,2,6,7	
X	GB 1 209 155 A (LES INDUSTRIES MUSICALES ET ELECTRIQUES P. MARCONI) 21 October 1970 * the whole document * -----	1,2,6,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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THE HAGUE	25 April 1997	Bollen, J

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